Silicon Controlled Rectifier (SCR)

Lecture – 16

TDC PART – I
Paper - II (Group - B)
Chapter - 5

by:

Dr. Niraj Kumar,

Assistant Professor (Guest Faculty)

Department of Electronics

L.S. College, BRA Bihar University, Muzaffarpur.

Silicon Controlled Rectifier (SCR)
Lecture – 16

TDC PART – I
Paper - II (Group - B)
Chapter - 5

- **SCR Turning-OFF Methods (PART – 4)**
- **Lecture Content :-**

➢ **(2) Forced Commutation**

➢ (I) Class-A Commutation : (Load Commutation)

➢ (II) Class-B Commutation : Self Commutated by an L-C Circuit (Resonant Pulse Commutation)

(2) Forced Commutation

- "In case of **DC circuits,** there is no natural current zero to **Turn OFF** the **SCR.** In such circuits, **forward current** or **Anode Current** must be **forced to zero** with an **external circuit** to **commutate the SCR** hence named as **forced commutation**".

- Unlike **Natural Commutation,** an external circuitry is required to forcibly bring the **SCR Anode Current below Holding Current** and keeping **SCR Reversed Biased** for a period more than the **SCR Turn OFF Time.** This technique is applied for **DC Circuit.** The commutation circuitry for **Forced Commutation** comprises of **Inductor** and **Capacitor.** This **Commutating Circuit** consist of components like **Inductors and Capacitors** called as **Commutating Components.** These **Commutating Components** cause to apply a **Reverse Voltage across the SCR** that immediately bring the current in the **SCR to zero.**

- **The SCR** can be **Turned OFF** by **Reverse Biasing** the **SCR** or **SCR Anode Curren**t reduced to a value below the value of **Holding Current** by using **External Circuit** made by **Active or Passive Components.** Since, the **SCR** is **Turned OFF** forcibly it is termed as a **Forced Commutation Process.** The **Basic Electronic and Electrical Component** such as **Inductance and Capacitanc**e are used as **Commutating Elements** for commutation purpose.

- **Forced Commutation** can be observed while using **DC Supply;** as we know there is no **Natural Zero** current in **DC Circuits** like as **Natural Commutation.** The current cannot go naturally zero in the application of **DC supply.** Hence, in the case of **DC Circuits,** the **Anode Current is forced to Zero.** The **External Circuit** used to force **Anode current to Zero** or below the **Holding Current** or applying **Reverse Voltage** is known as a **Forced Commutation Circuit.**

- So, **Forced Commutation** is used in **DC Circuits** hence it is also called as **DC Commutation.** The **External Circuit** used for **Forced Commutation** process is called as **Commutation Circuit** and the **Elements** used in this circuit are called as **Commutating Elements.** The commutating circuit is used to apply a **Reverse Voltage** across **SCR** the immediately **Reduce Current to Zero**.

- This **Commutating Circuit** requires commutating **Elements** like **Inductance and Capacitance** to forcefully reduce the **Anode Current** of the **SCR** below the **Holding Current value**, that's why it is called as **Forced Commutation.** This type of commutation circuit is used in the application where the device is dealing with **DC Supply** like **Chopper and Inverter.**

- Based on the manner in which the **Zero Current** achieved and arrangement of the **Commutating Components, Forced Commutation** is classified into **Five different types of Class such as Class A, B, C, D, and E.** There are several forced commutation techniques for SCR Commutation (Turn OFF).

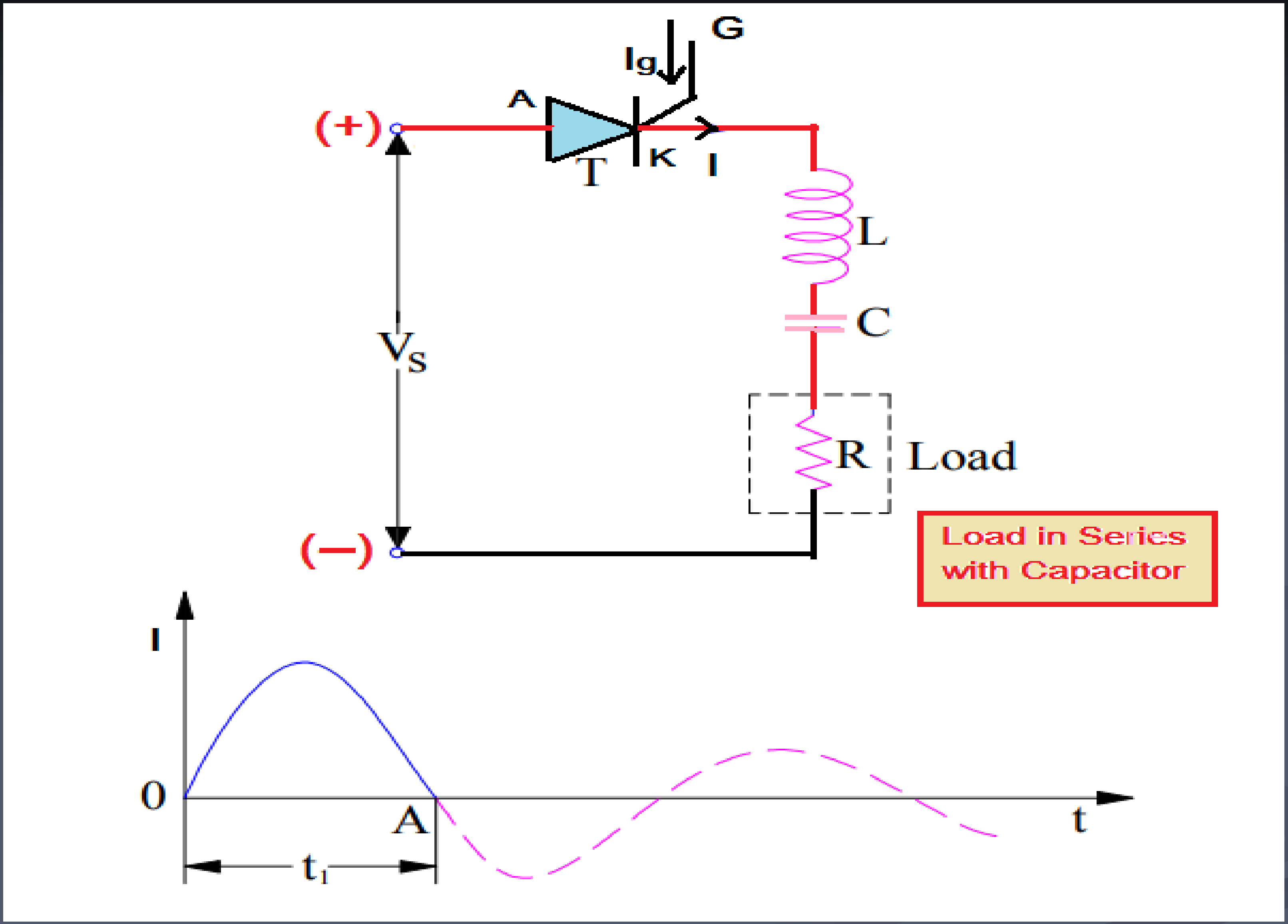
- **Forced Commutation** is divided into Five Categories, which are explained below :-

- **(I) Class-A Commutation : (also known as Load Commutation)**
- **(II) Class-B Commutation : (also known as Resonant Pulse Commutation)**
- **(III) Class-C Commutation : (also called Complimentary Commutation)**
- **(IV) Class-D Commutation : Impulse Commutation**
- **(V) Class-E Commutation : External Pulse Commutation**

(I) Class-A Commutation : (Load Commutation)

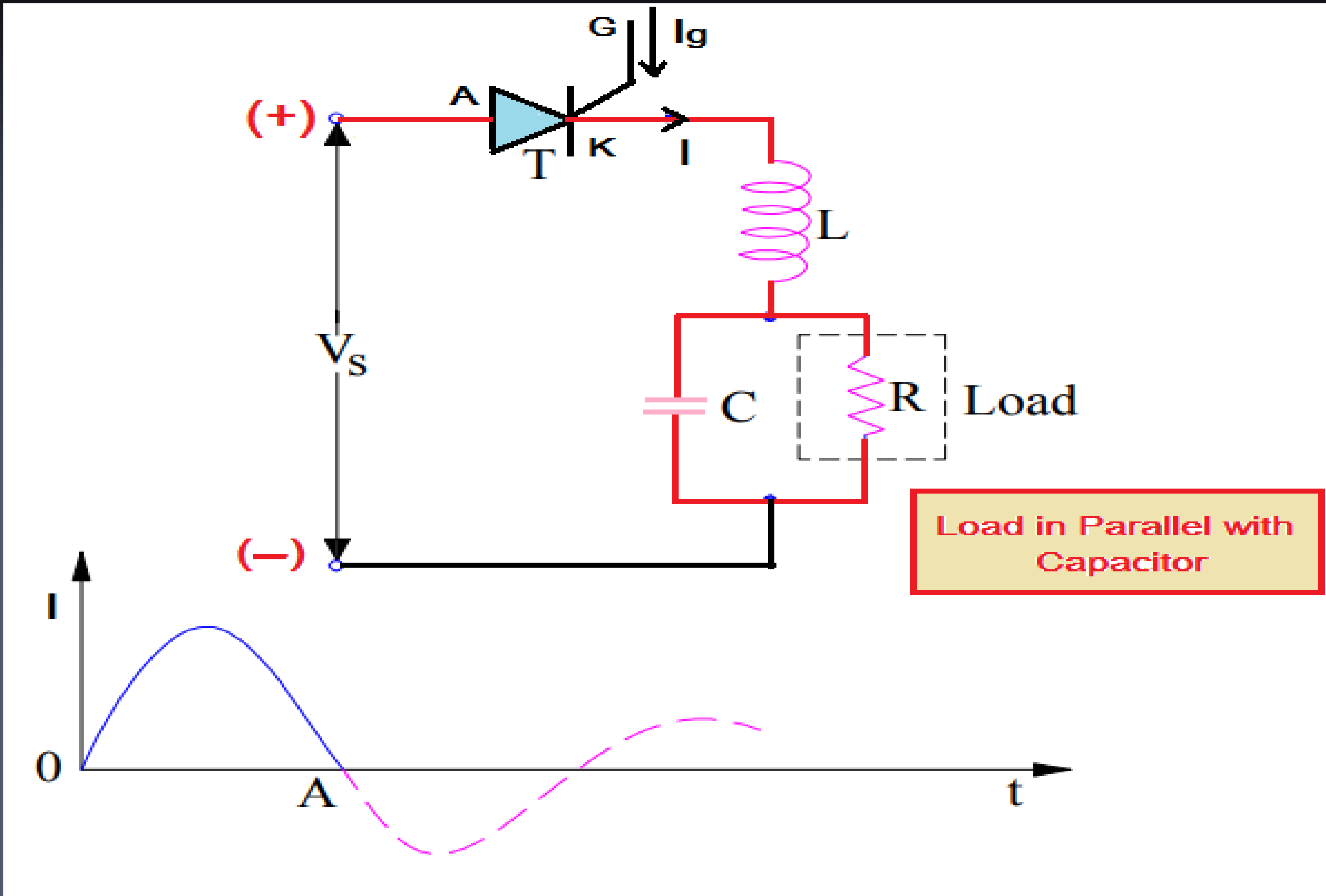
- **Class-A Commutation or Load Commutation** of **SCR** is a **Forced Commutation Technique** in which **SCR** is **Forced** to **Turn OFF**. In this commutation, the **Source of Commutation Voltage** is in the **load.** This load must be an **under damped R-L-C supplied with a DC supply** so that **natural zero is obtained. Turning OFF** an **SCR** essentially requires its **Anode Current** to fall below **Holding Current** and a **Reversed Biased Voltage** must be present across SCR for sufficient time so that **SCR** may regain its **Blocking State.**

- **Load Commutation of SCR** is also known as **Class-A** Commutation or **Self Commutation** or Resonant Commutation. In Load Commutation, **Capacitor (C)** & **Inductor (L)** are used as **Commutating Element or Components.** The **Commutating Elements** L and C are connected **either Parallel or Series** with the **Load Resistance (R)** as shown in **Fig (81) and Fig (82)** below with waveforms of **SCR Current (I_{SCR}), SCR Voltage (V_{SCR}), Gate Current (I_g)** and **Capacitor Voltage (V_c)** shown in **Fig (83). Commutating Element L and C** are connected in **series** with the **Load Resistance (R)** if the value of **Load Resistance (R) is low**. Circuit diagram for **Load Commutation** for low value of load **Resistance (R)** is shown in **Fig (81)** below.



- **Fig (81)** Shown a Circuit diagram for **Load Commutation** for low value of **Load Resistance (R)** in which Commutating element **L and C** are connected in **series** with the **Load Resistance (R).**

- If the value of **Load Resistance (R)** is high, **Inductor (L)** is connected in **series** with **Resistor (R)** whereas **Capacitor (C)** is connected across the load. This is shown in **Fig (82)** below.

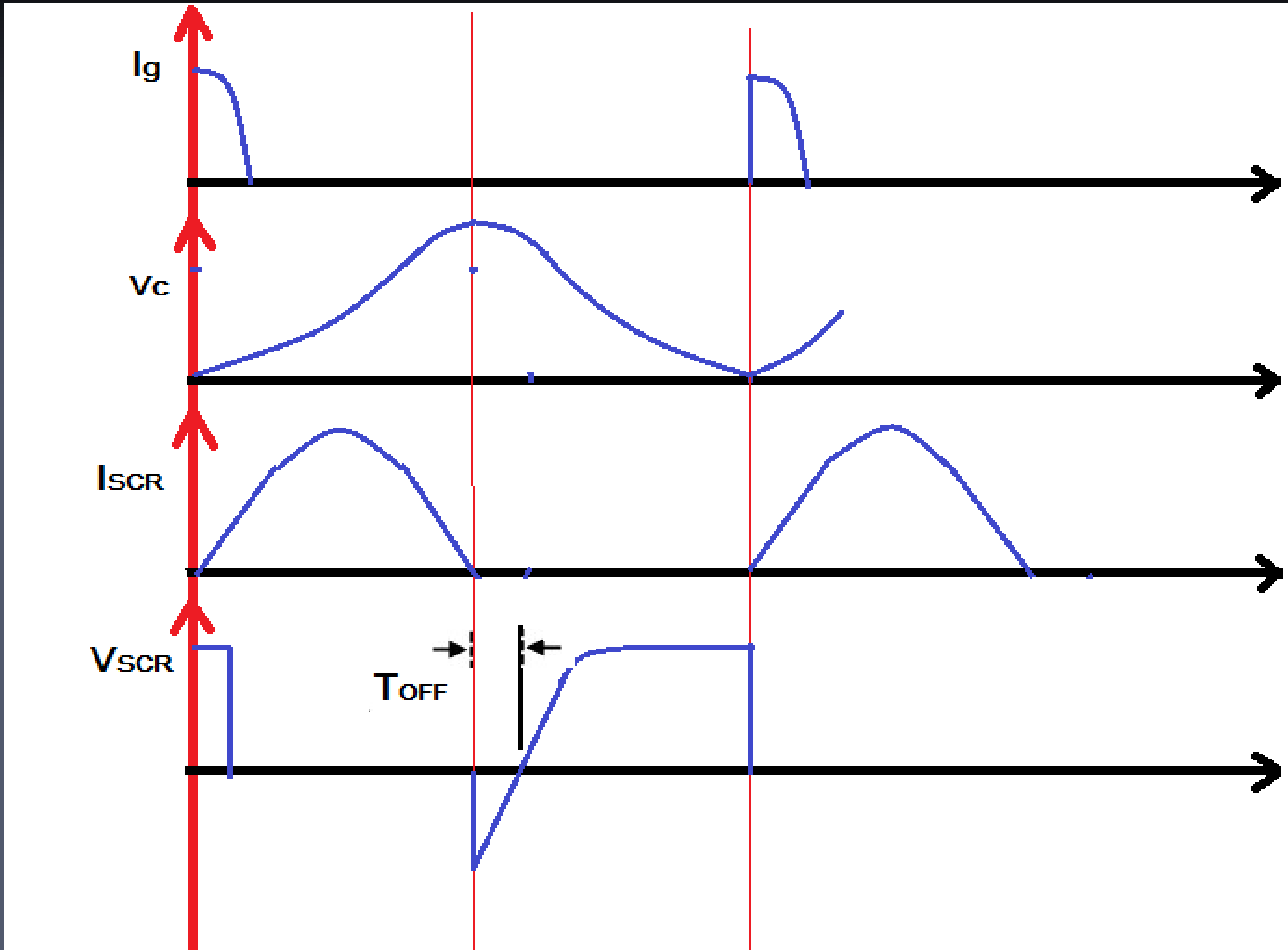


- **Fig (82)** Shown a Circuit diagram for **Load Commutation** for **High value** of **Load Resistance (R)** in which Commutating element **Inductor (L)** is connected in **series** with **Resistor (R)** whereas **Capacitor (C)** is connected across the Load **Resistor (R).**

- When the above circuit is energized from **DC Source,** current waveform as shown in **Fig (81) and Fig (82)** is obtained. As we can be seen, the circuit current is **under-damped in nature.** The Current is rising initially up to maximum and then begins to fall. When the current decays to zero **(Capacitor is fully charges at Instant A and hence will not allow further current flow)** and tends to reverse. During the time when SCR conducts, voltage across **SCR (V_T)** is zero.

- But as soon as current reaches zero and tend to reverse, a reverse voltage **(since capacitor C is fully charged up to source voltage Vs, this capacitor voltage is applied across SCR)** equal to the **Source Voltage (Vs)** is applied across the terminals of **SCR.** Thus after **Time A, Anode Current (I_A) of SCR is zero** and it is **Reversed Biased**. The two conditions of **SCR Turn OFF (Commutation)** are met and hence **SCR is Turned OFF** on its own at **Instant A.**

- The **Capacitor (C)** discharges through the **Load Resistance (R)** to make ready the circuit for the **next cycle of operation.** The time for switching **OFF** the **SCR** depends on the **Resonant Frequency** which further depends on the Inductor **(L) and Capacitor (C) components. From the above discussion, it is quite clear that the main idea behind Load Commutation Technique is to make an under-damped circuit. Since, SCR is getting Turned OFF on its own, this technique is also known as Self-Commutation or Resonant Commutation Technique.**



- **Fig (83)** Shown **Class-A Load Commutation** waveforms of SCR Gate Current (Ig), SCR Voltage (VSCR), SCR Current (ISCR) and Capacitor voltage (Vc).

- **Class-A or Load Commutation** is prevalent in **SCR** circuit energized from a **DC Source like Series Inverter.** The nature of the **DC circuit** should be such that when energized, the current should have a natural tendency to decay down to zero. **Thus Load Commutation is only possible in DC circuit not in AC circuit.**

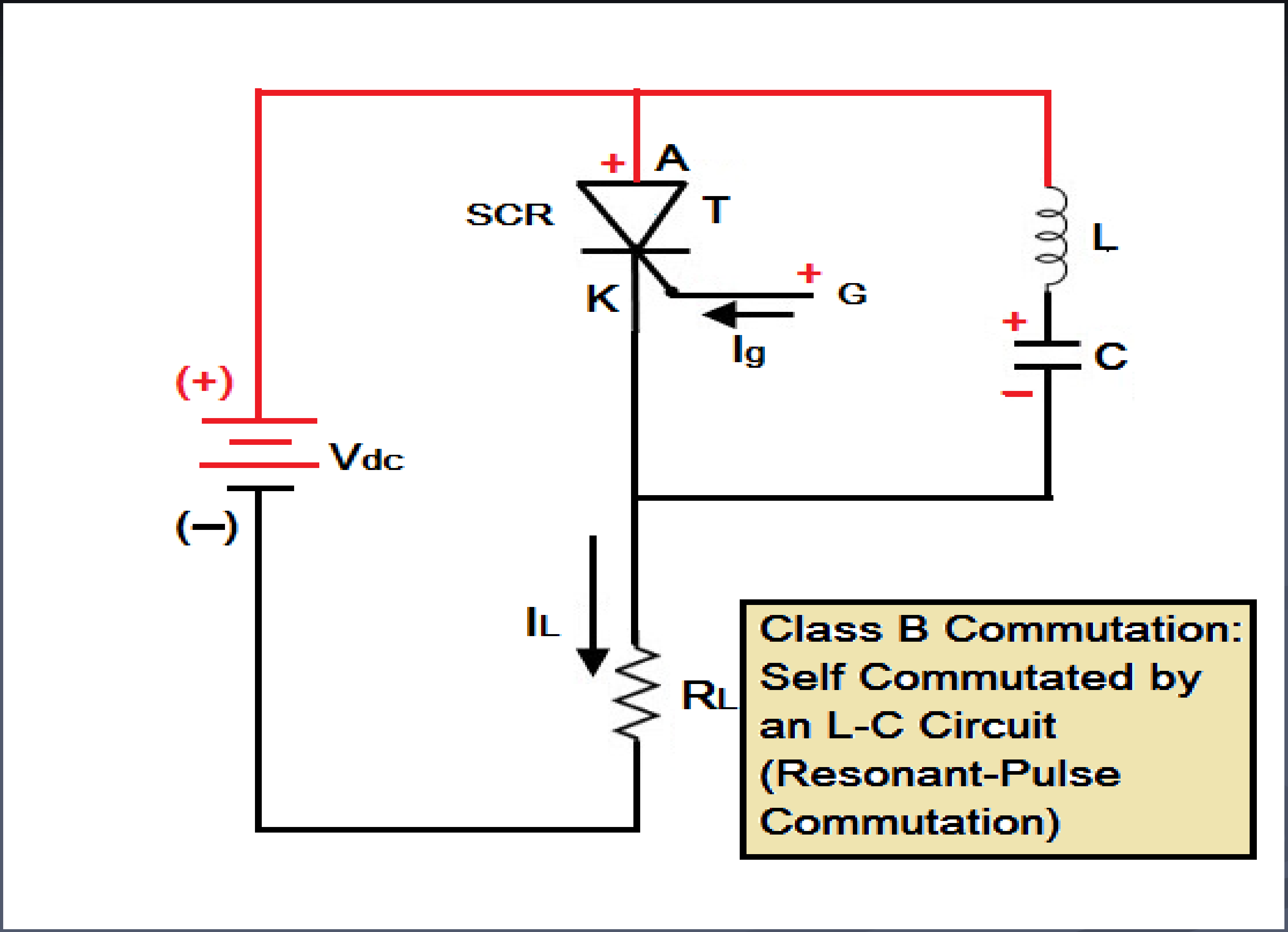
- This method is simple and reliable. For **high frequency operation** which is in the **range above 1000 Hz,** this type of **commutation circuits** is preferred due to the **high values of L and C components.**

(II) Class-B Commutation : Self Commutated by an L-C Circuit (Resonant Pulse Commutation)

- **Class-B Commutation or Self Commutation** by an **L-C Circuit** or Resonant Pulse Commutation is a **Forced Commutation** Technique to **Turn OFF an SCR.** In this technique, **SCR** is **Turned OFF** by gradual build-up of **Resonant Current** in the **Reverse Direction** i.e. from **Cathode (K)** to **Anode (A)** of **SCR.** This technique is also known as **Current Commutation** and occurs in **DC ircuit** not in **AC circuit.**

- This is also a **Self Commutation** circuit in which commutation of **SCR** is achieved automatically by **L and C components,** once the **SCR is Turned ON.** The major difference between the **Class-A and Class-B SCR Commutation techniques** is that in case of **Class-B Commutation,** the **L-C Resonant Circuit** is connected across (Parallel) the **SCR** but not in series with **Load Resistor (R)** as in case of **Class-A Commutation** and hence the **L and C components** do not carry the **Load Current (I_L).**

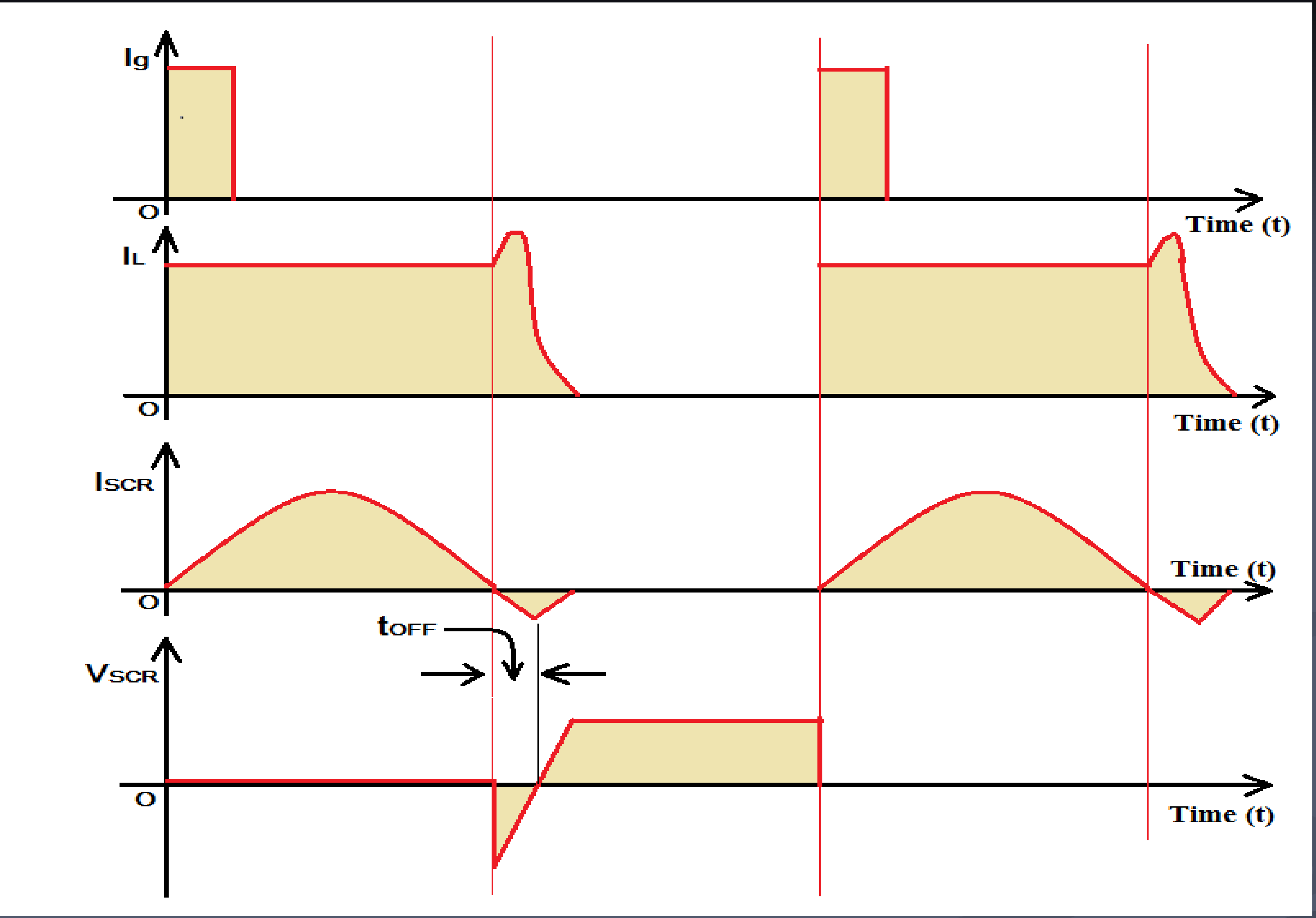
- The **L-C Resonant Circuit** is not directly connected with a load. **It is connected Parallel with the SCR**. Hence, the full **Load Current (I_L)** will not pass through the **SCR.** The circuit diagram of **Resonant-Pulse Commutation** is as shown in the **Fig (84)** below with waveforms of **SCR Current (I_{SCR}), SCR Voltage (V_{SCR}), Gate Current (I_g)** and **Load Current (I_L)** shown in **Fig (85).**



- **Fig (84)** Shown circuit diagram of **Class-B Commutation or Resonant-Pulse Commutation.**

- When the **DC supply** is applied to the circuit, the **Capacitor (C)** charges with an **upper plate Positive and lower plate Negative up to the Supply Voltage (Vdc)** and **SCR remains Reversed Biased** until the **Gate Pulse is applied.** When we apply the **Gate Pulse,** the **SCR is triggered,** and then the **SCR Turns ON.** When **SCR is Turned ON,** the **current will divide into two parts, one part** of a **Constant Current** will **flow** through the **SCR,** and the **second part** of a **Sinusoidal Current** will **flow** through the **L-C circuit.**

- Now from above discussion the current start flowing in two directions, one is through **Vdc+ – SCR – R – Vdc-** and another one is the **Commutating Current (Ic) through L and C components**. But, then the **Constant Load Current (I_L)** flows through the **Resistance (R) and Inductance (L)** connected in **series,** due to its **large reactance.** Then a **Sinusoidal Current** flow through the **LC Resonant Circuit** to **charge** the **Capacitor (C)** with the **Reverse Polarity.**



- **Fig (85)** Shown **Class-B Resonant Pulse Commutation** waveforms of SCR Gate Current (Ig), SCR Voltage (V_{SCR}) , SCR Current (I_{SCR})and Load Current (I_L).

- Once the **SCR is Turned ON,** the **Capacitor (C)** is starts **discharging through C+ – L – T – C-.** When the **Capacitor (C)** is **fully discharged,** it **starts charging** with a **Reverse Polarity.** Hence a **Reverse Voltage** applied across the **SCR** which causes the **Commutating Current (**I_C**)** to oppose the **flow** of the **Anode Current (**I_A**) or Load Current (**I_L**).**

- When the **Commutating Current (Ic)** is higher than the **Anode Current (I_A)** or **Load Current** causes **Anode Current (I_A)** of **SCR** is decreases and when the **Anode Current (I_A)** is less than the **Holding Current (I_H)** the **SCR** will automatically **Turn OFF** and the **Capacitor (C)** charges with original polarity.

- In the above process, the **SCR is Turned ON** for some time and then **automatically Turned OFF for some time.** This is a continuous process and the **desired frequency of ON/OFF depends on the values of L and C.** This type of commutation is mostly used in **Chopper Circuits.**

to be continued ....